WEST AFRICAN COCOA RESEARCH INSTITUTE

QUARTERLY PROGRESS REPORT

No. 48

GHANA
TAFO, ~~GOLD COAST~~.

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WEST AFRICAN COCOA RESEARCH INSTITUTE

TAFO, GHANA

FORTY-EIGHTH QUARTERLY REPORT

OCTOBER-DECEMBER, 1957

Any results recorded in this Progress Report should not be accepted as conclusive. The report contains interim information only. Final results are published in WACRI Technical Bulletins and elsewhere.

SENIOR STAFF

Director	J. Lamb
Deputy Director	C.G. Johnson (on leave 18th December)
Scientific Assistant to Director	G.A. Jones
Secretary	H.L. Pugh (on leave)
Assistant Accountant	J.N.A. Hyde (appointed 16th December)
Office Assistant/Librarian	Audrey Bryan

TAFO STATION

Division of Entomology	P.F. Entwistle (returned from leave 2nd October)
Division of Pathology	J.W. Blencowe
	A.L. Wharton
	A.A.F. Brunt
	A. Attafuah
Division of Botany	D.R. Glendinning
	R.G. Hurd
Division of Chemistry	T.A. Rohan
	R.H. Kenten (arrived 27th December)
	E. Margaret Holden
	R.K. Cunningham
Division of Agronomy	R.J. Benstead
	R.W. Smith (arrived 10th December)
	J.F. Longworth (arrived 10th December)
Laboratory Technicians (electronics)	A.J.H. Arnold
(spectrography)	J.C. Burridge (arrived 25th October)
Plantations Manager	H.W.S. Allison (on leave 27th November)
Maintenance Engineer	A. Maddison
Works Superintendent	E.K. Berko
Guide-Demonstrator	F.E. Decker (returned from leave 26th November)
Station Manager	S.E. Ntim Kwafo

IBADAN SUB-STATION

Deputy Director (Nigeria)	T.W. Tinsley
Entomologists	R.G. Donald
	C.K.H. Martini
Pathologists	J.M. Thresh (returned from leave 26th October)
	D. Kay

STAFF MATTERS

The Director visited Nigeria in November to inspect possible sites for the new plantation which is to be acquired for the Sub-Station, and in December he flew to Sierra Leone for a tour of the cocoa-growing areas there.

Mr. R.H. Kenten arrived at Tafo on the 27th December on secondment from Rothamsted Experimental Station as Biochemist. Mr. Kenten has taken over as Head of the Chemistry Division from Dr. Rohan, who will be leaving the Institute in January. Two new Agronomists, Mr. R.W. Smith and Mr. J.F. Longworth, joined the staff of the Institute in December, after a period of training at East Malling Research Station. Mr. J.C. Burridge arrived in October to set up and operate a spectrographic laboratory at Tafo.

VISITORS

In October the Institute was visited by Dr. C.A. Krug and Dr. A. Viton of the United Nations Food and Agriculture Organisation. Mr. John Cadbury of Bournville and Mr. D.H. Joss of the Cocoa, Chocolate and Confectionery Alliance, London, also visited Tafo in October. Other visitors have included Mr. O.J. Voelcker, C.B.E., a former Director of W.A.C.R.I.; Mr. J. Guilloteau, Director of the Inter-African Bureau for Soils and Rural Economy; and Mr. D.F. Safonov and Mr. V.J. Smirnov of the Russian Embassy in London.

The Agricultural Adviser to the Secretary of State, Mr. G.W. Nye, paid a short visit to the Sub-Station and discussed research problems with members of the staff. Mr. K.S. Hocking of the Colonial Pesticides Research Unit, Tanganyika, and Sayed Hassan Mitwakil, Assistant Director of Agriculture, Sudan, have also visited the Sub-Station.

MANAGEMENT AND MAINTENANCE

Work on the new buildings and extensions has made steady progress. Preliminary clearing of 38 acres of land for a large Fertilizer Trial has started.

CROP DELIVERY

The major crop reached a peak in October. Over the whole quarter 626,900 pods have been harvested, and 73,427 lb. of cocoa sold. From the recorded plots on the Old Station the total number of pods harvested was 20 per cent lower than the number collected over the same period last season. At the same time black-pod infection has increased considerably, the percentage discards rising from 3.1 to 10.2, and the number of

fermentable pods harvested has fallen by 24.6 per cent. Damage by pod miner and pod borer was still widespread, but mostly superficial. There was a general build-up of the capsid population in December and routine control measures were resumed.

SWOLLEN SHOOT DISEASE

Losses during the quarter from the Uniformity Trial Areas, Old Station, due to swollen shoot disease and other causes are given below.

Month	Trees destroyed		Total	Infected seedlings removed
	Swollen Shoot	Undiagnosed		
October	37	6	43	57
November	49	12	61	80
December	43	3	46	77
Total	129	21	150	214

A total of 1,282 infected trees were removed from the Square Mile and the Old Station

UPPER AMAZON SEED

Dispatches of F3 pods to Nigeria and the Cameroons during the quarter were as follows:

Western Region	9,455
Eastern Region	8,108
Northern Region	1,000
Cameroons	4,250

The allocation of F2 pods to contributing territories has been completed for this season; a total of 6,754 pods being distributed.

METEOROLOGY

Month	1957		19-year mean	
	Rainfall (in.)	Wet days	Rainfall (in.)	Wet days
October	5.19	19	9.09	18.6
November	3.74	13	4.14	10.8
December	2.72	8	2.36	6.1
Total	11.65	40	15.59	35.5

PATHOLOGY DIVISION

VIRUS RESEARCH

The results of a preliminary enquiry into the prevalence of undetected cacao swollen shoot virus in an area of randomly planted Amelonado cacao are now accumulating.

The observations were made in the 40-acre Block E on the Square Mile, which contained some 4,000 cacao trees and saplings occupying about 6 acres. The area had been inspected every month and infected trees removed; in November, 29 diseased trees were found and these, together with 96 'contact' trees, were coppiced to within 6 inches of soil level. In addition, 22 small and uneconomic patches of cacao totalling 486 trees were coppiced; these trees included two of the infected trees and 12 of the 'contacts'.

The results to date are that six of the 'contact' trees have shown symptoms of swollen shoot infection on the chupons growing from their cut stumps, and 41 of the 472 presumed healthy trees have been found to be infected. This high level of masked infection is not surprising, for swollen shoot virus has devastated most of the cacao in this district; it does, however, underline the difficulty of eradicating the disease even when inspection of the crop is frequent and highly skilled.

It has been found that stem swellings may develop on cacao seedlings which tests have shown to be virus-free. The swellings developed after a period of temporary dormancy, the abnormality occurring at the region on the stem where growth had resumed. Histological examination showed that the xylem tissues of the swollen stems were normal, but the phloem was definitely enlarged.

The series of tests on host plants and vectors of cacao swollen shoot virus has continued, one item of interest was the failure to infect Triumfetta rhomboidea, even when the plant was successfully grafted onto infected plants of the closely related species Heliocarpus popayanensis.

Work continues on the testing of cacao plants for resistance or tolerance to virus infection, but there is nothing further to report.

STUDIES ON BLACK-POD DISEASE

Effect of age and size of pod on susceptibility

Two years' records are now available for this experiment, although it will be some time before analysis of the 1957 records

is completed. The trees will be used next year for an experiment to study the development of young fruits protected from infection by Phytophthora palmivora Butl. Over 50 per cent more "black pods" were recorded in 1957 than in 1956. Table I shows the frequency of infections at different sites, on fruits less than 10 cm. in length (cherelles), immature fruits greater than 10 cm. long, and on ripe pods.

TABLE I

Age of fruits	Site of infection			Total
	Proximal	Lateral	Distal	
Cherelle	14	97	138	249
Immature pod	86	158	37	281
Ripe pod	18	74	9	101
Total	118	329	184	631

Site of infection records for different months of the year were given in Quarterly Report No. 47. Results for the whole season are given in Table II.

TABLE II

Month	Site of infection			Total
	Proximal	Lateral	Distal	
May	-	3	9	12
June	5	42	67	114
July	16	91	77	184
August	19	43	7	69
September	30	48	9	87
October	32	73	11	116
November	15	28	3	46
December	1	1	1	3
Total	118	329	184	631

N.B. Figures are for total infections, including multiple infections on single pods.

The typical pattern of spore infections giving two peaks of disease in the season is shown by the numbers of lateral infections. Distal infections from germinating spores are largely confined to cherelles, hence they are at a maximum only in June and July and not in October when there are few young fruits on the trees. Numbers of proximal infections declined after October and do not follow the pattern which would be expected if these infections arose from germinating spores. Isolations are being made from similar numbers of cushions which bore proximally, laterally and distally infected pods during each month of the year. So far, P. palmivora has been recovered only from those which bore proximally infected pods.

Strains of P. palmivora occurring in Ghana and Nigeria

Comparisons of isolates from widely scattered localities in Ghana have so far shown few differences in appearance and growth rates in artificial culture and in pods, nor in the dimensions of sporangia collected from artificially infected pods. Some results for isolates collected in cacao areas representative of Ashanti, Southern Ghana and Trans-Volta/Togoland are given in Table III.

TABLE III

Source of isolate	WACRI No.	Mean rate of growth (cm. per day)			Dimensions of Sporangia (u)		
		Oatmeal agar	Potato dextrose agar	Pods	Mean of 200		Ratio L/W
					Length	Width	
Mampong	G 7	1.74	1.06	3.27	39.1	23.5	1.66
Simpa	G22	1.92	1.50	3.93	47.7	23.8	2.00
Swedru	G31	2.32	1.62	3.71	50.2	25.8	1.95
Tafo	G53	1.91	1.49	3.80	51.9	25.7	2.02
Woropong	G49	1.90	1.34	3.58	47.5	24.4	1.95

The isolate number G7 from Mampong in Ashanti is the only one so far examined which showed consistent differences to a greater or lesser extent in all the characters investigated, including colony appearance on potato dextrose agar,

The culture collection of P. palmivora has been increased by the addition of isolates from diseased cushions and by an isolate of what is believed to be P. palmivora from diseased seedlings (see below).

Resistance and tolerance

Harvesting on the 1st Clonal Trial is almost complete and records for the numbers of "black pods" for each selection will shortly be analysed in relation to the figures for undamaged pods recorded by the Botany Division. Numbers of infected pods have been extremely high because diseased pods were left on the trees, and differences do appear to exist between selections. For example, selection A12 had an average of over 13 "black pods" per tree over the whole year, while clone ACU85, which in previous years has given high yields comparable with A12, had less than 2 "black pods" per tree.

Few "black pods" were recorded during the year on trees in the 9th Progeny Trial Area. However, despite the regular weekly harvests, levels of pod disease will probably build up as the yields of these young trees increase and detailed classification of diseased fruits will continue next year. Unfortunately, as in the 1st Clonal Trial, local areas of high disease inoculum are already developing and it is doubtful if all selections will be exposed equally to infection in the future.

Dieback of cacao seedlings

The most important finding during the quarter has been the recent isolation of Phytophthora species from diseased seedlings in the Botany nursery. Chant, in 1954 (see Nature, 180, 1494-5, 1957), found a species of Phytophthora responsible for a serious dieback of seedlings in Nigeria, and symptoms of the disease at Tafo are the same as those described by Chant. It was first reported in the nursery on the 14th December in a block of four-week-old T82 seedlings. Up to 37 per cent of the seedlings were dead or diseased although some were recovering by the development of axillary buds. The disease was extremely localized, a similar neighbouring bed of T82 seedlings, and two nearby beds of three-week-old Amelonado seedlings, being entirely unaffected.

The Phytophthora sporulated freely from affected material kept in humid chambers. It was isolated with ease, on to oatmeal agar, from pieces of infected stem previously surface sterilized in mercuric chloride. It was also recovered by first washing pieces of diseased material under running tap water for 12 hours and then transferring them either to oatmeal agar or to sterile wounds cut in the surface of cacao pods. A necrosis typical of black-pod disease developed from the wounds and the Phytophthora could be recovered from the pods into artificial culture. It

remains to be seen if the disease can be produced in healthy seedlings by the Phytophthora isolates obtained. P. palmivora is almost certainly responsible but specimens will be sent to the Commonwealth Mycological Institute for confirmation.

ENTOMOLOGY DIVISION

CAPSID STUDIES

Joint WACRI and Department of Agriculture Capsid Control Trials

Both large- and small-scale units of the new series of capsid trials (see Quarterly Report No. 46) have received their second application of insecticide. In the small-scale units, where aldrin, gamma-BHC and malathion were being compared, the latter treatment has been abandoned because of the poor results obtained. So far in this experiment little difference has been found between BHC and aldrin.

In the large-scale units endrin, so far, is giving the best control, whilst little difference has been apparent between aldrin and dieldrin.

MARMARA STUDIES

The incidence of pod-husk miner (Marmara sp.) in relation to ant and capsid spraying

In the previous Quarterly Report it was indicated that the rise in the incidence of the pod-husk miner (Marmara sp.; Lepidoptera, Gracillaridae) was associated with the use of insecticides against capsids or ants. Enough data are now at hand to demonstrate quantitively the truth of this contention.

At Oyoko some experiments have been made on the control of ants and mealybugs (see Quarterly Report Nos. 45, 46 and 47). In the treated area tree trunks were heavily sprayed with dieldrin - two applications with a two-month interval between, each application at 1 lb. of toxicant per acre - while no dieldrin was sprayed on the control plots. As indicated in the Table IV, the attack by Marmara was very high in the treated area, and very low in the control area. One hundred pods were sampled from each of several farms in the two areas, and the results can therefore be read directly as percentages. The degree of damage to the pod is expressed as the percentage of surface damaged by miner.

TABLE IV

Number of pods damaged by miner

Plot No.	Degree of damage (% pod surface covered by miner) 0	1-30	30-60	60-100
		Unsprayed Plots		
5a	77	22	0	1
5b	65	34	1	0
5c	55	44	1	0
5d	49	48	3	0
5e	54	45	1	0
5f	69	31	0	0
		Sprayed Plots		
2	0	5	13	82
3a	0	3	10	87
3b	0	3	7	90
3c	0	1	11	88
3d	0	11	15	74
1a	0	15	34	51
1b	0	9	13	78
4a	0	10	16	74
4b	0	15	26	59

In this example the control and treated areas were about one mile apart. It could be argued that the difference was one of locality rather than of treatment: though later surveys of other areas do not support this suggestion. Table V shows the result of a further survey on the W.A.C.R.I. Square Mile, where sprayed and unsprayed areas are close together and indiscriminately situated with respect to each other.

TABLE V

Percentage distribution of miner damage

	Degree of Damage (% pod surface attacked by miner) 0	1-30	30-60	60-100
Unsprayed Plots	18.3	35.6	18.9	27.2
Sprayed Plots	5.3	32.2	24.8	37.6

Again a lighter incidence is apparent on sprayed plots, but the difference is not so striking. The unexpected prevalence of miner on unsprayed plots may be because so much of the Square Mile is sprayed that the unsprayed areas are also affected. This suggestion is supported by the association found between miner incidence on unsprayed plots, and their distance from the nearest sprayed plot. Within about 300 ft. of a sprayed area the effect appears to be strong, but it falls off rapidly beyond this.

The rise in Marmara illustrates in a classical way how the application of a powerful insecticide, while having certain desirable effects, may inadvertently produce undesirable side effects. In any community animals and plants live by and on each other so that their population levels attain a quasi-stable state. If one of the regulating factors, say a potent parasite, is eliminated or reduced, a violent population surge of a hitherto unnoticed organism may occur: and like Marmara it may be economically significant.

The dangers are two-fold: that resulting from the effects of an increased Marmara population on husbandry; and the danger that, though the yield is not affected, the appearance of the pods may turn farmers from the otherwise beneficial effects of capsid control - effects which generally outweigh the small nuisance of increased Marmara.

It is, as yet, too early to say if the rise in Marmara is due to a specific chemical, or merely to an excess dosage of any of the chemical sprays now being used. But it would be wiser to attempt control of this new pest by careful manipulation of dosages and frequencies of existing anti-capsid sprays, rather than to apply still more different chemicals, so running the risk of producing other similar side effects, and still further complicating an already complex situation.

MEALYBUG STUDIES

Joint WACRI and Department of Agriculture trials on mealybug control

1. Oyoko. Mealybug populations in the treatment area are still at the very low level mentioned in the previous Quarterly Report, whilst those in the control plot have, during the quarter, exhibited the normal seasonal increase that is associated with the last three months of the year.

In order to ascertain the duration of control both

ant and mealybug counts will be continued until populations in the treated and control areas approach similar densities. Already the duration of virus vector control achieved is very promising and ant populations are still far below pre-treatment and control plot levels.

2. Isolated outbreaks. The experiments on isolated outbreaks will be wound up early in January 1958 and a full report made when the final results are available.

Mealybug populations have still not returned to their pre-treatment levels though a clear upward trend has been evident during the past three months. Ant populations approached closely to pre-treatment densities five months ago and have not declined to any great extent since then. There has been a steady build-up in the number of Crematogasterine nests present in the plots.

Due to the small area treated (2-3 acres) in these discrete outbreaks, little hope can be held for prolonged vector control as ant re-infestation has been relatively swift, when compared with Oyoko. Infection from outside may as easily take place when the ants are controlled as it may when the ant populations are normal, though in the first case wind-borne infective nymphs will have little chance of survival once they have attained the adult state. Before this, however, transmission may have occurred.

3. Square Mile. Though during the past quarter mealybug populations in the control area have exhibited a seasonal increase, those in the treated area have not shown any definite elevation, fluctuating between 9 and 19 per cent of pre-treatment levels.

However, the percentage of trees examined that were found to be infested rose early in the quarter to a level similar to that in the control area, a state which was still evident at the close of this period.

POLLINATION STUDIES

The effects of insecticides on pollination, setting and insect numbers

This experiment, which was set up in May 1957, involves three distinct blocks in the Old Station. One, the control, has been left complately unsprayed over the whole period, another has been sprayed monthly with gamma-BHC, and the third has been sprayed monthly with dieldrin. The treatments have been applied as canopy sprays, as in normal capsid control operations.

From May to July there was no difference in the amount of pollination in the three areas. Since July the number of

pollinated flowers has been too small to obtain any significant figures, but it seems unlikely that the situation has changed. Setting has followed the same pattern.

Insect counts are made each day at 6.30 a.m., 10.30 a.m. and 1.30 p.m. from the cacao flowers. At the beginning of the experiment, before spraying had started, the average number of insects per 100 flowers was similar in the three blocks. After the first spray the numbers in both the gamma-BHC and the dieldrin treated plots dropped to about 50 per cent of those in the control. In the latter the insect population very gradually increased towards the end of year from approximately 6 per 100 flowers to 12 per 100 flowers. The sprayed areas followed a similar pattern, but increased more rapidly from approximately 3 per 100 flowers in June to 10 per 100 in December.

No observable difference has been found so far between the gamma-BHC and the dieldrin sprayed areas.

The numbers of pollinating Ceratopogonid midges alone have been too small in all of the blocks to obtain any statistically significant results, but as far as can be seen they have not been affected by spraying.

BOTANY DIVISION

PLANT BREEDING AND SELECTION

Production of hybrids

It has been decided that the production of further hybrids, intended ultimately to provide new varieties for issue to the farmers, should cease for the time being. The hybrids now under trial are extremely promising, and it seems unlikely that with our present knowledge we could achieve further improvements of any consequence. In preparation for a future hybridisation programm however, investigations will continue on hybrids obtained by using parents representative of individual Amazon populations, such as Nanay, Parinari, etc., instead of the hybrid Amazon parents now used and also by crossing inbred generations of local types with Amazons. Studies on the variation in the response of different types to climate and soil conditions, and on the inheritance of disease resistance, tree habit, bean size and other aspects of quality will continue. The hybrids under test together with their respective parents are recorded in Table VI.

TABLE VI

A	-	WAE5	P4/9:J114/5	x T63/971	clones C18 x C74
B	-	WBE2	E1:C43/291	x T63/967	" C25 x C75
C	-	WBE3	E1:C43/270	x T63/971	" C23 x C74
D	-	WBE4	E1:C43/291	x T16/613	" C25 x C73
E	-	WEB1	T79/416	x E1:J92/70	" C68 x C26
F	-	WE6	T79/501	x T85/799	" C67 x C77
G	-	WE4	T60/887	x T60/888	" C42 x C43
H	-	WAE11	S84:E104/90	x T85/799	" C27 x C77
J	-	WEA3	Reciprocal of H.		
K	-	WBE6	W41	x T63/967	" C14 x C75
L	-	WEB3	Reciprocal of K		
M	-	WEA2	T79/467	x S72:J114/49	" C69 x C20
N	-	WEB2	T79/467	x E9:B31/195	" C69 x C22

Wet to dry cocoa conversion ratios

Experiments have been carried out to determine the degree of variation between Upper-Amazon varieties in the quantity of dry cocoa obtained from a given quantity of wet cocoa. The cocoa was fermented in small heaps enclosed in plantain leaves, the size of the heap depending on the amount of material available. The fermentation period and the time between harvesting and breaking were also varied, as convenient, and appeared to affect slightly the individual results obtained. Climatic conditions and degree of ripeness seemed also likely to be relevant.

The conversion ratio was calculated both from the total weights involved, and from the ratio of average bean-weights before and after fermentation, as determined from samples. The former will be affected by any losses of beans during the fermentation and drying process, while the latter will be liable to sampling fluctuations. In practice the two ratios generally showed close agreement, and the results given in Table VII, which shows the ratios obtained from different fermentations, are based on the average of the two estimates in each case. The variation within a variety is due in part at least to variation in the period between harvesting and breaking etc., as mentioned above. (See next page for Table VII)

The results show a considerable variation, from the low conversion ratios of T12 and T86 to the higher ratios of the pure-bred Nanays. In the past, when assessing the relative yielding capacities of different varieties an average conversion ratio has been applied, but the results of this experiment suggest that the variation in the conversion ratio is too great to be safely ignored.

TABLE VII

Types	Variety	Conversion ratios (percentages)
Scavina x ?	T12	34, 36, 35
Parinari x Parinari	T86	33, 38, 37
Nanay x Nanay	T61	46, 44
	T62	45
	T81	41, 47
	T92	41, 40
Nanay x ?	T11	37, 42, 41
	T15	41, 41
Iquitos x ?	T17	40
Nanay x Parinari	T60	44, 40
	T63	40, 38
	T76	40, 37
	T79	45, 41
	T82	39, 37
Nanay x Iquitos	T72	40, 39
	T73	42, 40
	T85	39
	T87	40, 38
Parinari x Iquitos	T65	40, 38, 39

Upper-Amazon Plots

A comparison has been made between the cocoa types planted in the first Amazon plots established by the Department of Agriculture throughout the cocoa-growing areas of Ghana. These plots were planted in 1949 and 1950, and are thus four years older than the Institute's first variety trials planted outside Tafo. Each plot contains two or more F2 types, planted normally in alternate double rows. These F2 types are from open-pollinated pods taken from the F1 trees at Tafo; thus only the female parent is known in each case, and each pod used in the planting could have had a different male parent.

Individual tree records are not usually available, but the mean number of pods obtained per tree up to June, 1957 can be calculated. Comparing the data from the Eastern Region plots alone there is a sufficient measure of consistency to indicate that in spite of being open-pollinated the types have retained a certain individuality. In all the Eastern Region plots the Nanay-Parinari hybrids (T60, 63, 76, 79 and 82) have produced more pods than the Nanay-Iquitos hybrids (T72, 73, 85, and 87), though this difference will be partly compensated by the tendency to large pods in the

Nanay-Iquitos types. Among the Nanay-Parinari hybrids themselves, the Na 32 x Pa 7 crosses (T60 and T79) gave more pods than the Na 32 x Pa 35 crosses (T63 and T82), though here again results from the F1 trees at Tafo suggest that differences in pod-size would tend to compensate. All the unapproved types gave consistently lower yields, and have a tendency to small pods.

Only type T12 (Savina) has given markedly inconsistent results, being the best type in the better plots, but poorer than the other approved types in the lower-yielding plots. Fertility varies considerably in the different plots, performances ranging from 30 pods per tree to less than two pods per tree, though most plots yielded more than 10 pods per tree.

When the plots in Ashanti and Western Region are included the picture becomes more confused. The Nanay-Parinari types retain the lead but when the different types are ranked according to yield individual varieties vary considerably in position from site to site. These inconsistencies may be due in part to different reactions to the varying climatic conditions. No attempt has yet been made to correlate the yield results with climate, for which in many cases data are not available, and it would be difficult to take adequate account of variation in shade conditions and capsid damage. Furthermore, the plots are not planted according to a statistical design, and an estimate of standard error is not possible. The plots may, however, provide information which will be useful as a guide to future work.

1st Clonal Trial

An analysis has been carried out on the yield data from the ten best varieties in the 1st Clonal Trial. This trial, which contains 20 varieties in square 16-tree plots with six replications, was planted in 1947. Data for the six seasons 1951-57 were used, and the calculations were based on the logarithms of the number of pods per plot per year.

The analysis of variance has shown a large block-variety interaction, against which the variety effects are not significant, though the total number of pods per variety ranges from 4,516 to 8,118. There is no evidence of a variety-year interaction, but there is some indication of a block-year interaction, which seems to be due largely to the poorer blocks coming into bearing later than the others.

The large block-variety interaction is apparently the result of the heterogeneous conditions within a block. On a

covariance analysis, using the method of Papadakis, in which the performance of a variety within a plot is compared with that to be expected from a consideration of the performances in neighbouring plots, the variety effects are found to be significant. The soil conditions in the 1st Clonal Trial area are probably more variable than they would normally be in a site chosen for a variety trial, but these analyses do indicate the difficulties involved in field trials with cocoa.

VEGETATIVE PROPAGATION

Fertilizer on cuttings

Confirming the results of the previous experiment of this type (see Quarterly Report No. 44 et. seq.) the fertilizer applications have not affected the percentage rooting, the speed with which the cuttings sprouted, or the rate of growth to date. The degree of shade, however, does appear to have an influence on the cuttings. As explained in the previous Quarterly Report, three shade treatments are being used - viz. 10 per cent sunlight, 25 per cent sunlight, and an initial 10 per cent followed by 25 per cent sunlight after a fortnight. These figures do not take account of the light lost on account of the polythene sheet, which with the grade used amounts to 17 per cent of incident light. Actual light intensities have been measured with a Weston exposure meter, taking several readings at different points, with the meter directed vertically upwards, to allow for shade variation. The results show the light intensities above the polythene sheet to be about 9 and 27 per cent sunlight respectively, corresponding to 7.5 and 22.5 per cent sunlight under the sheet (150 gauge).

The lower light intensity again promoted early budding but with the good-rooting selection (S27) the more rapid rate of growth under the higher light intensity soon compensated for this effect. Transferring the cuttings from 10 per cent to 25 per cent sunlight after a fortnight did not result in any lasting improvement.

The different light intensities have, however, had an appreciable effect on the proportion of successes obtained with the poor-rooting selection (A72), as shown in Table VIII, which shows the number of cuttings successfully rooted, starting with 80 cuttings in each case.

TABLE VIII

Percentage Sunlight	Number of cuttings successfully hardened	
	Selection	
	S27 (Good)	A72 (Poor)
10	78	65
25	77	15
10/25	75	38

It is apparent that whilst cuttings from an easily rooted selection will survive under either light intensity, the poor-rooting selection gives better results under the 10 per cent sunlight conditions. This effect warrants further attention as it may lead to improved rooting with "difficult" selections.

With both selections the original leaves appeared less healthy in the higher light intensity, but, particularly with the more easily rooted selection, the new shoot grew more rapidly in the stronger light. Table IX gives the mean shoot length after 12 weeks for the two selections.

TABLE IX

Percentage Sunlight	Selection S27 (Good)		Selection A72 (Poor)	
	No. of Plants	Mean length cm.	No. of plants	Mean length cm.
10	78	4.8	21	2.5
25	67	8.2	4	4.8
10/25	70	8.1	22	6.4

Comparison of different polythene thicknesses

It has been found that the polythene sheet used at W.A.C.R.I., which has been referred to as 300 gauge (i.e. 0.003" thick), is in fact 150 gauge (0.0015" thick). As this grade is rather fragile the Department of Agriculture has been using the thicker 500 grade (0.005" thick), and two experiments have been carried out to compare the two grades. With care the thicker polythene can last for a year or more with continuous use, but these experiments suggest that it is slightly inferior to the

lighter grade in rooting efficiency. In the first experiment 100 cuttings were placed under each grade of polythene, and successful results were obtained with 90 cuttings under the 500 grade, compared with 96 cuttings under the 150 grade. In the second experiment 150 cuttings of a different selection were used, of which 76 rooted successfully with the 500 grade, and 84 with the 150 grade. The differences are not large and it may be that the intermediate 300 grade will provide the most satisfactory combination of physical strength and rooting efficiency.

The thicker polythene transmits only 73 per cent of incident light, as against 83 per cent transmission with the lighter material, but the experiments described above would suggest that this is unlikely to be deleterious. It seems unlikely, too, that the gaseous permeability would be reduced sufficiently to account for the difference.

Transportation of cuttings at the "root initial" stage

A preliminary experiment has been carried out to test a method which has been used successfully with tea cuttings, for transporting rooted cuttings washed free from soil. The cuttings are removed from the rooting medium when they have just started root formation, and after washing they are packed in flat cellophane bags which are thensealed with sellotape. The bags consist of two layers of cellophane with a blotting-paper lining, and are 12" x 18", each bag holding ten cuttings. To maintain a high humidity 100 ml. of water are added per bag.

In this preliminary experiment the bags have been packed tightly into a wooden box, which was left for 48 hours in the boot of a car before the cuttings were finally removed and replanted. This is probably a more rigorous treatment than the cuttings would normally receive.

The first problem has been that even with a single selection the root initials are not produced simultaneously on all the cuttings. For example of 20 cuttings of a good rooting selection, R15, after three weeks one had roots up to 3 cm. long and more, another had several emerging roots all less than 1 cm. long, four were at the root initial stage, in six the base of the cutting was swollen, while in the remaining eight there was no sign of rooting. With a poor rooting selection, T17, of 90 cuttings none had reached the root initial stage after three weeks although several had swollen bases.

Despite this variation cuttings were taken out at weekly

intervals for the experimental treatment. All the cuttings appeared healthy when unpacked, with a bloom of moisture on the leaves. Table X shows the percentage success obtained to date, the replanted cuttings being inspected one month after reinsertion.

TABLE X

Selection	Days from setting to removal	Percentage at root initial stage	No. of cuttings removed	No. of cuttings survived
R15 (Good)	7	0	20	10
	14	5	20	17
	21	20	20	15
T17 (Poor)	14	0	20	0
	21	0	20	0
	28	0	10	0

While the good rooting selection has survived reasonably well whatever the stage of root formation, the poor rooting selection has failed completely. Further experiments are being carried out in an attempt to improve on these survival figures.

Stimulation of new chupon growth

In the experiment on the stimulation of chupon growth (see Quarterly Report No. 47) most of the techniques used have resulted in the production of two or three new chupons per plant. The best treatment, applied to nine seedlings, has given an average of 3.2 chupons per plant. In this treatment, which is based on the suggestion that leaves produce auxins which may inhibit lateral bud initiation, the terminal bud and all leaves on the distal half of the stem have been removed. Plants with only the terminal bud removed have given an average of 1.4 chupons per seedling.

If the terminal bud is split longitudinally two new chupons are produced, provided the operation is carried out carefully and the wound is protected until it has healed. One of these chupons, however, is invariably larger than the other and eventually becomes dominant; the smaller chupon usually dies. It seems unlikely, therefore, that this technique will provide a useful method for increasing the amount of chupon material available for cuttings.

CHEMISTRY DIVISION

SOIL FERTILITY

Effect of major nutrients on cocoa

The 1957-58 harvest is now almost complete. In the Shade and Manurial Trial at W.A.C.R.I. the yields to date show extremely significant responses to the removal of shade and to the application of a complete major nutrient fertilizer mixture (N:P:K:Ca:Mg). Yields, in terms of lb. dry cocoa per acre, are given in Table XI.

TABLE XI

Yields (lb. dry cocoa per acre)				
Pretreatment Period			Treatment Period	
1954-5	1955-6	1956-7		1957-8 (to 31.1.58
24	32	211	Shade without fertilizer	581
20	27	204	Shade with fertilizer	820
21	18	173	Shade removed only	1002
20	29	170	Shade removed, fertilizer applied	1495

On the shaded plots low to medium shade is provided mainly by Gliricidia. The cocoa used in the experiment consists of 10-year old Amelonado, planted at 8 ft. x 8 ft.

In the 2^4 N,P,K,Mg seedling experiment at Bunso, girth measurements six months after application indicate that all major nutrients are having beneficial effects. The N effect almost attains significance at the 5 per cent level.

Establishment experiments

The establishment experiment on clear-felled land, with different protective cover crops, is proceeding satisfactorily. After one year "bare soil" and "elephant grass mulch" treatments are significantly better than the other treatments, viz. natural regeneration, grass, Commelina, and Crotalaria juncea.

In an establishment experiment on exposed soil (old village sites) an N,P,K.Mg mixture with a Guatamala grass mulch are showing significant effects.

COCOA PREPARATION AND QUALITY

As mentioned in the previous Quarterly Report a new technique has been devised for the rapid fermentation of West African Amelonado cocoa. Several tons of cocoa have now been fermented in this way, with satisfactory results. The technique involves fermentation of the beans in four-inch deep layers on slatted trays, without mixing, for a total period of two to three

days. The fermented cocoa is dried in the same trays, thus minimising labour costs. Full details of these experiments are being prepared for publication.

On the basis of the experimental results achieved over the past two years, certain recommendations can now be made for the fermentation of West African Amelonado cocoa. It is not considered practical to lay down a standard set of conditions for cocoa fermentation based only on the duration and on frequency of mixing. The fermenting mass should be examined from time to time, and the decision to start the drying stage should be based on the appearance of the bean mass. Certain general principles have, however, been established, and they are recorded here more as a guide than as a directive.

1. Six days fermentation is too long for this variety.

2. The minimum weight of cocoa which should be fermented in a heap is 150 lb. A heap of this size may be fermented for four days, with one mixing after 24 hours.

3. If mixing is to be of any value the first treatment should be given after 24 hours. In relatively small heaps of up to 600 lb. wet cocoa one mixing may suffice, but with larger heaps a second mixing may be necessary.

4. The changes associated with fermentation occur much more slowly in sweat boxes than in heaps due to lack of aeration. With these boxes, containing one ton of wet cocoa, the most efficient technique has been found to be a four to five day fermentation, with mixing after 24 and 48 hours.

5. Very small heaps of the order of 20 lb. wet cocoa can be fermented successfully but the surface area per unit volume and heat losses through radiation are greater than with larger heaps. Such small quantities of cocoa should not be fermented separately under natural conditions as a low night temperature or heavy rainfall can depress the temperature of the fermenting mass sufficiently to delay or even to prevent the death of the beans within a reasonable time.

Studies on cocoa enzymes

The rate of inactivation during fermentation of several enzymes has been further investigated with heaps of cocoa varying in size from 200 lb. to 2,000 lb. wet weight of beans. Peroxidase and polyphenol oxidase determinations have been made in addition to those of the other enzymes (β-glucosidase, amylase, catalse etc.) which were determined in the preliminary work. Fully fermented

wet beans contain little if any of most enzymes and even polyphenol oxidase, which is assumed to be responsible for the oxidative changes that take place during drying, appears to be reduced to less than ten per cent of its original level.

A paper on enzymic aspects of fermentation is being prepared for publication.

I B A D A N S U B - S T A T I O N

PATHOLOGY SECTION

VIRUS RESEARCH

The control of cocoa swollen shoot virus by eradication methods

In 1950, the Department of Agriculture decided that the usual method of attempting to eradicate outbreaks of cocoa swollen shoot disease in Nigeria would be to cut out all the trees found with symptoms and the adjacent apparently healthy trees occurring within 30 yards of the nearest known infection. Between 1950 and 1956 this policy was successful in that most of the treated outbreaks were eradicated by an initial cutting out treatment followed by one or more retreatments where additional infected trees were found. However the measures involved the destruction of large numbers of apparently healthy trees and an average of 10 of these were destroyed for every tree found with symptoms.

At the time the 30 yard treatments were introduced there was no evidence to indicate that the removal of apparently healthy trees on such a liberal scale was justified, but in 1954 a series of coppicing experiments was started to give information on which to base a more rational policy for treating outbreaks of swollen shoot disease. In the course of this work all the apparently healthy trees around 80 outbreaks were not uprooted but coppiced and the new growth made from the cut stumps was kept under regular observation for virus symptoms. Infected stumps were uprooted on discovery and on 35 plots records were made of the distribution of the infected stumps in relation to the standing trees found with symptoms at the time the coppicing was carried out. Around 62 other outbreaks the trees immediately adjacent and in contact with those found with symptoms were cut out and the remaining apparently healthy trees within 30 yards were coppiced

and the stumps kept under regular observation.

A provisional examination of the data from the coppicing experiments has recently been made, although a final analysis of the data will not be possible for some months, as infected stumps are still being found on some of the plots coppiced in 1957 or late 1956. It is already clear, however, that there is great variation in the number of infected stumps found at the coppiced sites, even around outbreaks of similar size. This is to be expected because the outbreaks were selected at random from those being treated by the Department of Agriculture between 1954 and 1957. Consequently, they were not all treated at the same time of year and the condition of the trees varied from site to site; while there was also variation in tree density. Furthermore, there were likely to be differences in the number, type and behaviour of the mealybugs on trees in the various outbreaks treated. All these and other factors are likely to have influenced the rate at which the outbreaks were spreading at the time they were treated and consequently the number of infected stumps found after coppicing.

In general more infected stumps were found around large outbreaks than around small ones. However, the ratio of infected stumps to the number of standing trees found with symptoms at the time of coppicing was at a maximum for the smallest outbreaks. This indicates that small outbreaks are spreading at a more rapid rate than large ones, a conclusion which is substantiated by observations made on the uninterrupted spread of virus in infected farms and which is to be expected from the fact that the ratio of infected trees to healthy trees in contact with them is at a maximum for the smallest outbreaks.

The number of infected stumps occurring around the treated outbreaks decreased rapidly with increasing distance from the infected trees which were found with symptoms and cut out at the time of coppicing. Of the infected stumps occurring within thirty yards of the cut out trees, 51 per cent occurred within five yards, 35 per cent occurred between five and ten yards, 8 per cent occurred between ten and fifteen yards and the remaining 6 per cent occurred between fifteen and thirty yards. Many of the infected stumps were of trees which were in the initial latent phase of infection at the time they were coppiced. The steep gradient of their occurrence around the treated outbreaks is therefore consistent with the observation that cocoa swollen shoot

virus spreads slowly compared with other viruses and particularly when compared with the spread of certain fungi. The steep gradients are also consistent with the conclusion that most of the spread of cocoa swollen shoot virus takes place by the movement of mealybugs for a limited distance through the cacao canopy and to a much lesser extent by the windborne spread of mealybugs through the air. However, the movement of mealybugs through the air is of great importance and is responsible for the so called "jump spread" of the disease, when infections appear some distance from the virus source and separated from it by a zone of healthy trees. There is little information on the incidence and extent of satellite outbreaks but the occurrence of infection in 0.4 per cent of the trees occurring between 25 and 30 yards from the centres of infection in the coppicing experiments indicate that significant amounts of spread may take place over considerably greater distances.

The distribution of infected stumps was similar around outbreaks of all sizes, but the intensity of infection in the stumps around large outbreaks was higher than the intensity around small ones. Around outbreaks containing more than fifty infected trees four per cent of the stumps which occurred within 30 yards were found to be infected, compared with 1.4 per cent infection in the stumps around outbreaks containing 6-50 infected trees and 0.7 per cent infection in the stumps around the smallest outbreaks. These intensities are underestimates, as observations on the new growth from the coppiced stumps are not complete. Moreover the observed intensities should be increased to allow for the coppiced stumps which died before they were found with symptoms and recorded. The number of infected stumps which were missed in this way is impossible to determine, but records show that one-third of all the coppiced stumps failed to regenerate and as healthy stumps are known to regenerate more successfully than infected ones it is reasonable to assume that only half the infected stumps have been recorded in the course of the experiments. However, even when the observed intensities of infection are doubled it is clear that there is rarely any justification for treating the apparently healthy trees around outbreaks of all sizes to a distance of thirty yards.

The available data for the incidence and distribution of infected stumps in the coppicing experiments confirms the conclusion previously reached empirically, that large outbreaks

are more difficult to eradicate than small ones. Most of the treated outbreaks which contained less than ten obviously infected trees would have been eradicated by cutting out the trees found with symptoms, or these trees together with the apparently healthy ones which were in contact with them. By comparison, only a small percentage of the larger outbreaks would have been eradicated by such simple methods and the results of the coppicing experiments indicate that the apparently healthy trees around an outbreak should be cut out to a depth depending upon the number of infected trees found with symptoms at the time the treatment is carried out.

In deciding on the actual details of the cutting out measures to be adopted for the various outbreaks it is necessary to balance the additional missed and latent infections which are eradicated by a more drastic treatment, against the increased number of apparently healthy trees which this would involve. The data from the coppicing experiments enable this to be done and it is now recommended that apparently healthy trees should be cut out to a distance of five yards around outbreaks of less than 6 obviously infected trees, to a distance of ten yards around outbreaks containing 6-50 infected trees and to fifteen yards around the larger outbreaks. If this is done the evidence from the corrected data indicates that the intensity of latent and missed infections in the remaining apparently healthy trees immediately outside the cut out areas will on the average be less than five per cent. It is considered more economical to rely on these infections being found by the survey parties during the reinspection of the standing trees around cut out areas, than to attempt to eradicate them by more drastic initial treatment methods.

The number of apparently healthy trees involved in a cutting out treatment tends to increase as the square of the distance to which they are cut. This means that the latest proposals which have been made for eradicating outbreaks of swollen shoot disease in Nigeria are likely to result in considerable economies, compared with the original policy of cutting out the apparently healthy trees around outbreaks of all sizes to a uniform distance of thirty yards. Over the last year provisional changes were adopted for the control of virus outbreaks and the number of apparently healthy trees cut out in the treatment of outbreaks totalling 10,379 infected trees was reduced from an estimated 90,947 (which would have been cut out if the 30 yard treatments had been applied) to 55,351; a saving of 35,596 trees

on which the sum of £7,119 would have been paid out in compensation if the trees had been destroyed. If the latest recommendations had been adopted only 24,822 trees would have been cut out and a further 30,529 trees would have been saved.

STUDIES ON "DIE-BACK" OF CACAO

Existing areas

The experiment started on three plots of peasant cocoa at Araromi (Western Region), to compare the rate of increase in existing areas of "die-back", where trees treated with insecticides against capsids are compared with control unsprayed trees,has now been running for three months.

The results will be fully analysed when data are complete. In all the plots some of the marked areas of "die-back" increased; but in a greater proportion the position remained static.

Fungi isolated from capsid lesions and mechanical wounds

An analysis of fungi obtained from cultures of sections from two hundred and fifty capsid lesions gave 41 per cent Botryodiplidia theobromae Pat., 24 per cent Fusarium decemcullulare Brick, 28 per cent various fungi and 7 per cent sterile. The results from one hundred of these lesions that had definitely arise from single feeding punctures, showed that 93 were infected by fungi and 7 were sterile. An analysis of the fungi in twenty-nine occluded mechanical lesions gave 42 per cent F.decemcellulare, 21 per cent B.theobromae, 28 per cent were sterile and 9 per cent were infected by various fungi.

It is not intended to make a further analysis of fungi in capsid lesions, because they are likely to show only slightly different percentages of the two fungi, F.decemcellulare and B.theobromae. When available, more mechanical lesions will be examined to compare the fungal flora of wounds with the data already obtained on capsid lesions.

The effect of the presence of Calonectria rigidiuscula (Berk & Br.) Sacc. in coppiced stumps, on the regeneration of cacao

There has been no change in the percentage of stumps which have regenerated. A further ninety trees are being coppiced, which will be inoculated with pure strains of a laboratory culture of Fusarium decemcellulare Pat.; an imperfect stage of C.rigidiuscula.

Isolation of fungi from "die-back" areas

Sixty-three areas of "die-back" from eight trees were examined. In longitudinal section, the majority of cases showed a distinct greyish area of dead wood delineated from the living wood by a black line. In some, a water-soaked area existed between this black line and the living wood. These water-soaked areas in some cases adjoined the black line along the whole of its length and in others only in isolated patches.

In a few cases this distinct zonation did not occur; the wood that had been dead for some time was distinct, but the "black line" extended from one to twelve inches, with a decreasing intensity of colour along its length resulting in an overall diffuse black appearance.

In culture, 30 per cent of the 63 "die-back" areas gave F.decemcellulare, 30 per cent B.theobromae, 10 per cent various fungi and 30 per cent were sterile. The water-soaked areas were usually sterile but sometimes yielded F. decemcellulare. When a water-soaked area was apparent F.decemcullulare was usually isolated from the black line. When no water-soaked area was apparent B.theobromae was usually isolated from the black line. The diffuse-black areas all gave F.decemcullulare isolates. It is suggested that "die-back" areas may be either 'active' or 'static' and that there is a different fungal flora in the two forms.

Some 400 areas of "die-back" have been marked on thirty cocoa trees. These areas are to be examined weekly and cultures will be made when they are in an active state.

Laboratory experiments

Twenty Amelonado seedlings have been artificially inoculated, ten with F.decemcullulare and ten with B.theobromae in an attempt to induce "die-back" under laboratory conditions.

Attempts to cause wilting on three-week-old cacao seedlings by extracts from F.decemcullulare and B.theobromae grown on cassava-dextrose agar and on a nutrient solution, have been unsuccessful. The experiment will be repeated and different medias will be tried.

The effect on "die-back" of irrigation during the dry season

Thirty-seven trees in a cacao plot of seventy-four trees are being irrigated. Water is applied by hose at five-day intervals, each application being equivalent to one inch of rain. Every area of "die-back" on the seventy-four trees has been scored and at

monthly intervals any change in these "die-back" areas will be noted. At the same time any new areas of "die-back" will be recorded and where possible the mode of origin determined.

Termites

A survey carried out at Araromi on twenty mature cocoa trees, showed that twenty-five per cent of the areas of "die-back" and wood of half-an-inch or more in diameter, were infested by termites. These termites were identified as Neotermes aburiensis (Sjost) by Mr. W.A. Sands of the Colonial Termite Research Unit. Further surveys showed that the reproductives began the colony in dead wood. When the colony increased in numbers, and the dead wood was heavily infested, attack commenced on living wood. The damage was often relatively extensive and borings penetrated into six to eight inches living wood. It was noted that when the attack was heavy on living wood a distinct, black zone in the adjacent "die-back" area was rarely found.

It is intended to make further observations on the association of these termites with "die-back" areas.

ENTOMOLOGY SECTION

MEALYBUG STUDIES

In an area of derelict and semi-derelict cocoa on Moor Plantation which has been handed over to the Substation by the Federal Department of Agricultural Research in Nigeria counts of mealybugs on two contiguous plots were started during the quarter. The trees in these plots were planted between 1932 and 19 and have since been so severely damaged by capsids and "die-back" that many have been reduced to stumps or bare plots, or have died. In 1951 one of the plots was abandoned and bush and creepers have been allowed to grow up since then. Weeds in the other plot have been controlled by frequent cutlassing. The former plot will be referred to as the "bush plot" and the latter as the "cleared plot" in this report.

Only trees which still carry a reasonably full canopy are being examined in the present survey. As Planococcus kenyae (Le P.) and P. citri (Risso), which are very similar in field characteristics, together form the vast majority of all mealybugs present in the plots, it has been necessary to mount specimens from almost every colony for microscopical examination. Complete data, with specific identifications are at present availab

for only six trees in each plot. The records taken include the size of each colony, numbers of adults and nymphs present, the presence of predators, attendant ants, and ant tents, and details of the site of each colony on the trees.

The twelve trees carried 625 colonies (range 22 to 99 per tree) containing 2,526 mealybugs (range 29 to 437 per tree) of which 33.4 per cent of colonies, containing 18.9 per cent of the total mealybugs consisted of unidentifiable nymphs. P.kenyae was the most abundant species in both plots, accounting for 38.6 per cent of colonies and 67.4 per cent of total mealybugs. Only 4.8 per cent of the total mealybugs, representing 12.6 per cent of the colonies, were identifiable as P.citri. The difference in mean colony size between these two species, namely 7.2 and 1.6 bugs per colony respectively, suggests that P.citri may move more readily from the parent colony than does P.kenyae. If this is so the proportion of the former among the scattered unidentifiable nymphs may well be much higher than the relative abundance of adults of the two species suggests.

The trees on the bush plot carried a slightly higher population of mealybugs than those on the cleared plot but due to the small number of trees involved this difference has little or no significance. The most striking differences occurred in the distribution of two of the less common mealybug species and in the ratio between adults and nymphs. Fifteen colonies of Pseudococcus njalensis Laing, containing 131 specimens, were found in the bush plot but this species has not so far been encountered in the cleared plot. P. concavocerarii James, on the other hand, was represented only by a single adult from the former plot and by thirteen colonies containing 25 individuals in the latter. The ratio of adults to nymphs, taking all species together, was 1:5.1 in the bush plot and only 1:1.7 in the cleared plot.

Other mealybug species present included Ferrisiana virgata (Ckll.), Pseudococcus bukobensis Laing, Pseudococcus sp. nr. gahani Green, and Pseudococcus sp. nr. proteae Hall.

The most favoured feeding sites were in cankers, terminal buds and at the junctions of leaf blades and petioles. Only seven pods were on the twelve trees, and all were free from mealybugs.

Ants were in attendance on 106 colonies (17.0 per cent), of which 86 (81.1 per cent) were attended by Crematogasterine ants. These were more numerous in the bush plot, particularly on one tree.

The study of the mealybug population on these plots continues.

MINOR PESTS

A third species of Ricaniidae has been reared from a nymph feeding on cocoa; nymphs probably representing two other species of this family were also collected but failed to reach the adult stage. Nymphs of a species of Flatidae have been found feeding on young chupons and fan flushes.